Heat Conduction Beyond Fourier

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A linear irreversible thermodynamic framework of heat conduction in rigid conductors is introduced. The deviation from local equilibrium is characterized by a single internal variable and a generalization of the entropy current density via a current intensity factor. A general constitutive evolution equation of the current density of internal energy is derived by introducing linear relationship between the thermodynamic forces and fluxes. The Fourier, Maxwell-Cattaneo-Vernotte, Guyer-Krumhansl, Jeffreys type and Green-Naghdi type equations of heat conduction are obtained as special cases [1]. Based on these theoretical considerations, numerical demonstration of the basic properties of the general heat conduction equation is presented. These calculations use jump initial conditions with constant temperature boundary conditions in a one dimensional rod, in order to illuminate the differences of the above special theories and the advantage of our general framework. A report of promising ongoing experimental investigations is also provided.

[1] http://arxiv.org/abs/1108.5589, submitted to Journal of Non-Equilibrium Thermodynamics